



Evaluation of the normal tibial tubercle-trochlear groove distance with magnetic resonance imaging in a Turkish population

Evaluation of tibial tubercle-trochlear groove distance

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Abstract

Aim: Patellar instability is a common multifactorial knee pathology with a high recurrence rate. In this condition, the symptoms often continue and result in the patient becoming susceptible to chondromalacia and osteoarthritis. Tibial tuberosity-trochlear groove distance (TT-TG) is very important in the evaluation of patellofemoral joint instability. In this study, we investigated the normal value of TT-TG distance in men and women of different age groups and evaluated the reliability of magnetic resonance imaging (MRI) in TT-TG distance measurement. **Material and Method:** The study was carried out between January 2017 and December 2017 on 99 patients over the age of 18, all reporting knee pain but presenting with normal knee examination and MRI findings. The patients with abnormal findings on knee MRI or physical examination were excluded from the study. **Results:** The mean age of the patients was 41.1 ± 11.0 years with a median of 40 (18–68) years. The mean TT-TG distance in the whole population was 9.3 ± 3.3 mm, with a mean value of 9.9 ± 3.6 mm in men and 8.8 ± 3.0 mm in women. Within the male and female patient groups, the TT-TG distance did not significantly differ by age ($p = 0.646$ and $p = 0.570$, respectively). **Discussion:** In the present study, no significant difference was identified in the TT-TG distance measurement between males and females in different age groups. From the results of this study, it can be concluded that MRI is a reliable method for the evaluation of TT-TG distance.

Keywords

Knee; Magnetic Resonance Imaging; Tibial Tuberosity-Trochlear Groove

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Introduction

Tibial tubercle-trochlear groove (TT-TG) distance was first described by Goutallier et al. [1] in 1978 in a radiography obtained on the axillary plane, is an important parameter when determining the level of external tibial torsion or the lateralization of the tibial tubercle. Excessive tibial torsion may result in patellar maltracking, and a TT-TG distance greater than 20 mm may lead to patellar instability [2].

Patellar instability is a common multifactorial knee pathology that affects women more than men [3]. In addition to its high rate of recurrence, symptoms may continue in many patients, making them susceptible to chondromalacia and osteoarthritis [4]. The horizontal distance between TT and TG has been introduced as a symbol of external patellar instability [5,6]. Although computerized tomography (CT) scanning is recommended for TT-TG measurement, its interrater reliability is lower than 60 percent. It is also very difficult to determine the deepest point of the trochlear groove, and for this reason, significant measurement errors may occur [6].

MRI can evaluate soft tissue at a higher accuracy and does not involve radiation, and therefore its use is recommended for the pathologic diagnosis of patellofemoral ligaments [7]. In the present study, we evaluated the reliability of MRI in the measurement of the TT-TG distance and determined the normal values for this distance in males and females from different age groups based on knee examination and MRI findings.

Material and Method

This study was carried out between January 2017 and December 2017 on 99 patients over the age of 18 whose knee examination and MRI findings were normal. Patients having a complaint of knee pain and MRI results with a radiology report were included in the study. A knee examination was considered normal when there was no positive point except for sensitivity in the knee in the physical evaluation. The patients with abnormal findings on the knee MRI or knee examination were excluded from the study. In the MRI reports, images with no positive findings other than mild to moderate effusion were considered normal. The MRI images were obtained using TR 2560 and TE 30, and a section thickness of 4 mm on a 1.5 Tesla MRI scanner. The images were obtained when the knee was fully extended and quadriceps relaxed, and the scans were analyzed on the workstation (Philips MR Workspace 2.6.3.4, 2012). The TT-TG measurements were undertaken on fat-suppressed proton-density-weighted turbo spin-echo axial sequences using the technique described by Wittstein et al. [10]. The midpoint of the distal insertion of the patellar tendon to tibial tuberosity was determined, and the cursor was placed at this point (Figure 1a). Then, the first image, where the cartilaginous trochlear groove was completely visible, was displayed on the screen. The cursor position was marked on this new image (Figure 1b), and a reference line was drawn along the posterior femur condyles, with a second line drawn perpendicular to this reference line from the deepest point of the trochlear groove. One more line was drawn perpendicular to the reference line from the point marking the cursor, and the distance between these two perpendicular lines was recorded as the TT-TG distance (Figure 1c).

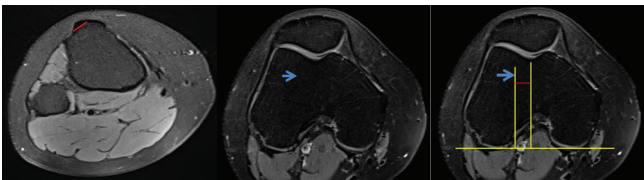


Figure 1. The midpoint of the distal insertion of the patellar tendon to tibial tuberosity was used as a measurement tool (a); The cursor was placed at this point and the images were shifted to the first image where the cartilaginous trochlear groove was completely visible. The cursor position was marked on this new image (b); The reference line was drawn along the posterior femur condyles, with a second line drawn perpendicular to this reference line from the deepest point of the trochlear groove. One more line was drawn perpendicular to the reference line from the point marking the cursor, and the distance between these two perpendicular lines was recorded as the TT-TG distance (c).

Statistical Analysis

A statistical analysis was carried out and evaluated using SPSS version 22.0 software (SPSS Inc., Chicago, IL). Descriptive statistics were expressed as mean \pm standard deviation, median (minimum-maximum), frequency distribution, and percentages. The variables were tested for conformity to normal distribution using visual (histogram and probability graphs) and analytic methods (the Shapiro-Wilk Test), and the variables were determined for normal distribution. A Mann-Whitney U test was used to assess statistically significant differences between two independent groups, whereas a Kruskal-Wallis Test was employed for the comparison of three dependent groups. The relationship between the variables was analyzed using Spearman's correlation coefficients. A *p* value of <0.05 was considered statistically significant.

Table 1. Ages, age groups, sexes and TT-TG values of the patients

	(n=99)
Age (years), mean \pm SD / median (min-max)	41.1 \pm 11.0 / 40 (18-68)
≤ 30 years, n (%)	16 (16.2)
31-50 years, n (%)	62 (62.6)
≥ 51 years, n (%)	21 (21.2)
Gender, n (%)	
Male	45 (45.5)
Female	54 (54.5)
TT-TG (mm), mean \pm SD / median (min-max)	9.3 \pm 3.3 / 8.7 (3.7-18.4)

n: Number of Patients; mean: Mean; SD: Standard Deviation; TT-TG: Tibial Tubercle-Trochlear Groove

Results

A total of 99 patients were evaluated in the study, with a mean age of 41.1 ± 11.0 years and a median of 40 (18-68) years. Of the patients, 54.5 percent (*n* = 54) were female and 45.5 percent (*n* = 45) were male. The mean TT-TG distance in the total study population was 9.3 ± 3.3 mm (Table 1). The mean TT-TG distance was 9.9 ± 3.6 mm in men, 8.8 ± 3.0 mm in women, 10.2 ± 3.9 mm in patients aged ≤ 30 years, 9.2 ± 3.2 mm in patients from 31 to 50 years, and 8.9 ± 3.1 in those aged ≥ 51 years (Table 2). There was no significant difference in the TT-TG distance between age groups and sexes (*p* = 0.618 and *p* = 0.131, respectively) (Figure 4). Similarly, within the male and female patient groups, the TT-TG distance did not significantly differ by age (*p* = 0.646 and *p* = 0.570, respectively) (Table 3, Figure 5).

Table 2. Distribution of the TT-TG distance by age group and sex

	n	mean ± SD / median (min-max)	TT-TG (mm)	p
Total	99		9.3±3.3 / 8.7 (3.7-18.4)	-----
Age groups				
≤30 years	16		10.2±3.9 / 9.5 (5.7-18.4)	0.618*
31–50 years	62		9.2±3.2 / 8.4 (3.7–16.6)	
≥51 years	21		8.9±3.1 / 8.7 (4.9–15.6)	
Sex				
Male	45		9.9±3.6 / 8.9 (3.7–17.9)	0.131**
Female	54		8.8±3.0 / 8.1 (4.7–18.4)	

n: Number of Patients; mean: Mean; SD: Standard Deviation; TT-TG: Tibial Tubercle-Trochlear Groove; *Kruskal-Wallis Test; **Mann-Whitney U Test

Table 3. Distribution of the TT-TG distance across age groups within male and female patient groups

mean ± SD / median (min-max)		n	TT-TG (mm)	p*
Male	Age groups			
	≤30 years	9	10.2±3.6 / 8.9 (5.9–17.9)	0.646
	31–50 years	30	9.6±3.7 / 8.9 (3.7–15.7)	
	≥51 years	6	11.0±3.8 / 11.2 (5.6–15.6)	
Female	Age groups			
	≤30 years	7	10.3±4.5 / 10.1 (5.7–18.4)	0.570
	31–50 years	32	8.9±2.8 / 8 (4.7–16.6)	
	≥51 years	15	8.1±2.8 / 8.1 (4.9–13.0)	

n: Number of Patients; mean: Mean; SD: Standard Deviation; TT-TG: Tibial Tubercle-Trochlear Groove; *Kruskal-Wallis Test

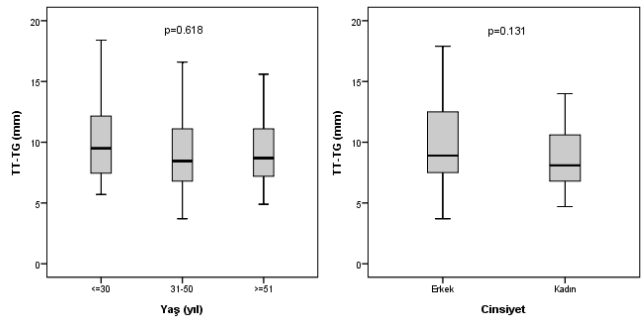


Figure 4. Distribution of the TT-TG distance according to age and sex

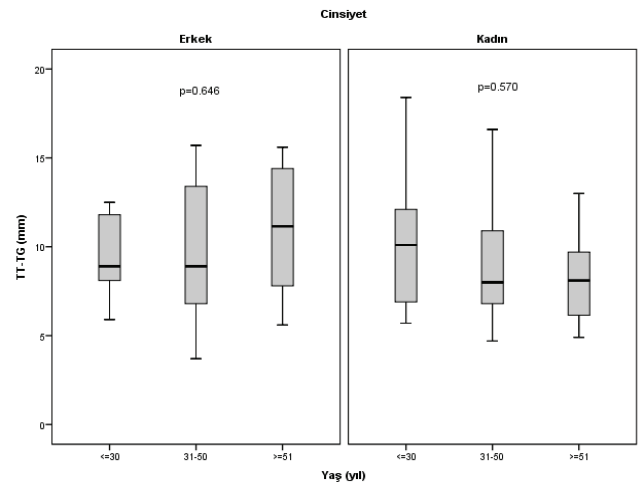


Figure 5. Distribution of the TT-TG distance across age groups within the male and female patient groups

Discussion

In the present study, the mean TT-TG value was found to be 9.3 ± 3.3 mm, with no significant difference between the age groups or sexes. MRI presents as a reliable method for the evaluation of the TT-TG distance and helpful in the identification of patella pathologies.

The position of the tibial tubercle is very important for the normal functioning of the quadriceps mechanism and determining the withdrawal direction of the inferolateral force vector on the patella and the quadriceps mechanism [2]. Normally, tibial tuberosity is placed on a line below the femoral sulcus, meaning that the magnitude of the inferior force vector is greater than the lateral force vector. This prevents the lateral subluxation of the patella. However, the size of the lateral force vector increases when the tibial tuberosity is placed further toward the lateral, and this leads to lateral subluxation and dislocation toward the patella [2].

TT-TG distance is one of the most important parameters in determining the lateralization of tibial tuberosity and external tibial torsion and plays an important role in the evaluation of patellar instability [8]. The TT-TG distance can be measured accurately using both CT and MRI, although several studies have suggested that the interrater reliability rate of CT measurements can be low [9,10]. The latter only evaluates bone structures and is associated with the high radiation doses [11]. MRI offers several advantages over CT, such as providing better visualization of the joint cartilage and soft tissues, being free of radiation, and allowing the evaluation of cartilage damage due to recurrent patellar dislocation [11,12]. An additional advantage of MRI is that it can help to determine the exact center of the area where the patellar tendon bonds to the tibial tuberosity [12] and identify patients that require tracheoplasty, as well as assist in preoperative planning [12]. Studies have revealed that MRI is a reliable preoperative evaluation method [6].

In different study groups, there is a high variability in normal TT-TG values. In the study by Pandit et al. [11], 100 patients with suspected meniscus injury and normal arthroscopy were examined, and the mean TT-TG distance was found to be 10 ± 1 mm; 9.91 mm in males and 10.04 mm in females, while Wittstein et al. [13]found the mean value of TT-TG distance to be 9.4 ± 0.6 mm. In another study, Schoettle et al. [12] compared the reliability of CT scanning with MRI and calculated the mean TT-TG value as 13.5 ± 4.6 mm on MRI, which is higher than the value reported by Pandit et al. [11] and Sobhanardekani et al. (14). Hingelbaum et al. compared the MRI scans of 200 knees using similar to Shoettle et al. method and found that the TT-TG values of the different sexes were not statistically different, with the mean TT-TG distance in the control group being 7.5 ± 3.5 mm compared to 13.5 ± 4.1 mm in the patient group [15]. In the study conducted by Sobhanardekani et al. [14]in Iranian patients, the mean TT-TG distance was reported to be 10.9 ± 2.5 mm, with similar TT-TG values between sexes. In the adult Indian population, the mean normal value of the TT-TG distance was calculated as 13.54 ± 6.22 mm (13.19 ± 6.28 mm in males; 14.07 ± 6.06 in females) [2].

The differences in the inclusion/exclusion criteria of the patients and the adopted MRI technique, measurement method, and sample size and characteristics may explain the differences

in the values reported in the literature. These different results may also be due to the ethnicity of the patients included in the study. This study was designed to determine the normal value for TT-TG based on the MRI results of patients without knee pathologies and is the first of its kind in Turkey in this respect. In the literature, the inter-rater and intra-rater reliability of TT-TG measurement via MRI has been reported to be less than 10 percent. This study has shown that MRI is a reliable method for the evaluation of TT-TG [7,11,14,16].

Conclusion

In this study, no significant difference was found in the normal TT-TG values according to age or sex. Based on the results, MRI seems to be a reliable method for the evaluation of TT-TG, which can assist in the identification of patella pathologies.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

None of the authors received any type of financial support that could be considered potential conflict of interest regarding the manuscript or its submission.

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